CAPTURING PROCESS KNOWLEDGE FOR FACILITY DEACTIVATION AND DECOMMISSIONING

FEBRUARY 10, 2009

Savannah River National Laboratory
Savannah River Nuclear Solutions
Aiken, SC 29808

Prepared for the U.S. Department of Energy Under Contract Number DE-AC09-08SR22470

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REVIEWS AND APPROVALS

Author, Joseph K. Santos, Environmental Science and Biotechnology Date

Manager, Environmental Science and Biotechnology Date

Work Sponsor, DOE-EM Office of D&D and Facilities Engineering Date

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LIST OF ACRONYMS

Acronym	Definition
CAD	Computer Aided Design
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	Contaminant of Concern
COLEX	Column Exchange
D&D	Deactivation and Decommissioning
DOE	Department of Energy
EM	Environmental Management
FIMS	Facility Information Management System
HIM	Historical Information Manager
HSA	Historical Site Assessment
HVAC	Heating, Ventilation and Air Conditioning
IPT	Integrated Project Team
LLNL	Lawrence Livermore National Laboratory
LOI	Lines of Inquiry
MARSSIM	Multi-Agency Radiation Site and Survey Investigation Manual
MC&A	Material Control and Accountability
MEL	Master Equipment List
NNSA	National Nuclear Security Agency
NRC	Nuclear Regulatory Commission
ORAD	Operations and Regulatory Affairs Division
ORPS	Occurrence Reporting and Processing System
P&ID	Process and Instrument Diagram
PCBs	Polychlorinated Biphenyls
PEP	Project Execution Plan
PGDP	Paducah Gaseous Diffusion Plant
PH	Process History
PK	Process Knowledge
RCRA	Resource Conservation and Recovery Act
RMMA	Radioactive Materials Management Area
S&M	Surveillance and Maintenance
SAT	Space Action Team
SDD	System Design Description
SNL	Sandia National Laboratory
SRS	Savannah River Site
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
USEC	United States Enrichment Corporation
USEPA	United States Environmental Protection Agency

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1.0 EXECUTIVE SUMMARY

The Department of Energy (DOE) Office of Environmental Management (EM) is responsible for a vast number of facilities at numerous sites around the country which have been declared excess to current mission needs. When such excess facilities are scheduled for Deactivation and Decommissioning (D&D), the responsible project team is faced with the task of evaluating them to plan for the removal, characterization and disposition of all legacy materials and process equipment. In this report process knowledge (PK) for D&D is defined as that body of knowledge about a process facility that allows the facility to be safely and effectively placed in its final end state. The main elements of PK for D&D are knowledge of the process design and knowledge of the history of operations that occurred in the facility during the operating phase of its life cycle.

The initial activity of the work reported herein was a survey of the general field of knowledge management (KM), with the goal identifying KM strategies that can be implemented by D&D project teams to manage the acquisition of PK. Next, Lines of Inquiry (LOI) were developed to assess how various organizations in the DOE complex acquire and use PK for D&D projects. These LOI were sent via email to several DOE sites. Responses to the LOI were evaluated to identify commonalities and best practices in approaches to capturing PK needed for D&D. The PK management practices of the Department of Defense and the commercial nuclear industry that are potentially relevant to D&D of DOE facilities were also surveyed. Out of these conclusions, the recommendations listed below naturally flowed.

1.1 RECOMMENDATIONS FOR D&D PROJECT EXECUTION AND INDEPENDENT REVIEW TEAMS

For teams assigned to conduct or review a facility D&D project, the following approach is recommended based on the conclusions presented in section 4.0:

1. It is recommended that a formal PK management program be developed. Consider centralizing program responsibility in the position of information manager. See sections 3.1.1 and 3.1.2 for approaches taken by SNL and LLNL, respectively. Taken together, these approaches can be considered best practices in the area or knowledge management.
2. The information manager should set up a paper or electronic document management system which is accessible to all project team members. The system should contain all key facility process design documents discussed in section 4.1 and its subsections. Specific recommendations identifying key elements of process design to be collected are discussed in section 5.1.2.
3. The information manager should also manage the interview process, including arranging, performing and documenting interviews with current and former employees who have been identified by project team members as potential sources of information. The information manager should seek help from people experienced in the interview process or be willing to become an expert in this discipline.
4. As concluded in section 4.1, several key documents that define the design of process facilities have been found useful by D&D project teams. Therefore, the following categories of documents

are recommended to be collected and made available to members of the D&D project team to perform their individual functions.

- Process and Instrumentation Diagrams
- Process Flow Diagrams
- Equipment Arrangements
- Specifications for Materials and Process Equipment
- Master Equipment List
- Line List
- System Design Description
- Equipment Vendor Documents
- Operations Training Manuals
- Safety Basis Documents

5. The following process history documents are recommended for review by the D&D project team:
   - Records of nuclear and chemical materials used or stored
   - Records of spills and leaks
   - Records of on-site disposals, if any
   - Deactivation final report
   - Surveillance and Maintenance (S&M) plan
   - Production reports
   - S&M records and annual reports
   - Lessons learned reports
   - DOE Occurrence Reporting and Processing Systems database events for the facility
   - Technical reports related to process development or performance
   - Results of interviews with people knowledgeable of facility history
   - Radiological surveys during the life of the facility
   - Historical aerial photographs
   - Control room operating logs
   - Material Control and Accountability reports
   - Facility condition reports or assessments

1.2 RECOMMENDATIONS FOR FACILITY TRANSTION TEAMS

The above recommendations for D&D project execution teams and independent review teams are also applicable to facility transition teams.

- An operating history (including previous operational records) of the facility giving the process knowledge of the nuclear and chemical materials that were handled and major spills or leaks that occurred

- A description of the condition of all structures, existing engineered protective barriers, and systems installed to prevent migration of both hazardous and radioactive contamination to the environment and that ensure the safety of workers, the public, and the environment
- A description of the nature, levels, and probable extent of the existing hazardous chemical contamination, the radiological contamination, and direct radiation fields within and around the facility
- An accurate and complete inventory (including associated uncertainties) of types, forms, quantities, and locations of all special nuclear and fissionable materials
- An inventory or estimate and the locations of the remaining hazardous material, waste and chemical inventories, and any associated uncertainty, including form and distribution information
- The occupational hazards associated with the facility. This evaluation should focus on fixed hazards. Temporary occupational hazards created to support operations and maintenance should be removed by the operations organization.
- Current radiological survey data, which will be used to identify barriers necessary to protect the public and the environment and define the radiological working conditions, equipment (e.g., containment, protective clothing, etc.) or procedures that protect the worker.
- The facility's shutdown status. As a minimum, the facility safety envelope; S&M requirements; the preservation of facility structures, systems, and components; safeguards and security; emergency plans and procedures should be addressed. Baseline information on energy utilities systems and services should also be included.
- A list of:
  - documents that define the authorization basis and the S&M requirements necessary to maintain the current safety envelope of the facility;
  - applicable permits, licenses, and agreements that remain imposed on the facility;
  - outstanding commitments to regulatory authorities, tribal governments, stakeholders, and DOE organizations that require action; and
  - excess equipment and material not required to operate and maintain the facility and that is planned to be removed from the facility
- Information on any other factors such as potential future use, long-range site plans, facility condition, and potential health, safety, and environmental hazards that could influence the selection of decommissioning alternatives (safe storage, entombment, dismantlement, etc.) or deactivation alternatives (thermal stabilization, residue elimination, separation of utilities, etc.).

2.0 INTRODUCTION

The Department of Energy (DOE) Office of Environmental Management (EM) is responsible for a vast number of facilities at numerous sites around the country which have been declared excess to current mission needs. In addition, there are hundreds of additional facilities from other DOE program offices, such as the National Nuclear Security Agency (NNSA), the Office of Science and the Office of Nuclear Energy which have reached or soon will reach the end of their useful life. These facilities are also being considered for transfer into the EM program for ultimate disposition. They are typically old, some dating back to the Manhattan project of World War II. They often have had multiple missions involving different production processes over their lifecycle. In the cold war environment in which they operated, a premium was placed on maximum production and rapid facility modification to meet the evolving needs of the weapons complex. Consequently, not only did many different processes operate within a facility over time, but documenting the design and operational history of these processes was commonly of secondary importance to production. Therefore, their design and operational history is often uncertain.

Additionally, since the end of the cold war and the termination of weapons production, many of them have been in a state of surveillance and maintenance (S&M) with minimal budget after production ceased. They have typically been used for storage of legacy materials and equipment that originated in other facilities at their sites. This occurred because it was more economical to simply transfer legacy materials and equipment from one facility to another rather than characterize and properly dispose of them.

When such excess facilities are scheduled for Deactivation and Decommissioning (D&D), the responsible project team is faced with the task of evaluating them to plan for the removal, characterization and disposition of all legacy materials and process equipment. The characterization process is considerably easier if equipment design information is available that addresses potential material holdup (e.g. internals that may have surface contamination or contain bulk materials), weights, and potential presence of hazardous materials (beryllium, lead, cadmium, etc.). Knowledge of the types of process materials that flowed through the equipment during its operational history is highly desirable, as well. Furthermore, the equipment removal activity is easier if the way it was designed and installed is known.

2.1 PURPOSE AND OBJECTIVE

The objective of this report is to identify the key elements of the body of process knowledge (PK) about a facility that are highly desirable, if not essential, to have in hand when planning for D&D of that facility. If such a body of PK is available, the D&D project cost and schedule will be greatly improved over the situation in which the required PK is not available to the integrated project team (IPT). In addition, a full body of PK will likely result in reduced health and safety risk to D&D workers. The scale of the DOE D&D program and the complexity of situations that must be addressed add weight to the importance of understanding the benefits of assembling an acceptable level of PK early in project planning. Thorough understanding of the radiological and chemical process history of systems, structures, and components informs the facility characterization effort, greatly improving

characterization efficiency, with resultant reduction in cost and schedule. In some situations, a full body of PK may nearly eliminate the need for a costly and time-consuming sample and/or survey program.

2.2 METHODOLOGY USED TO ASSESS PROCESS KNOWLEDGE ACQUISITION IN THE COMPLEX

Organizations across a wide spectrum of industries are concerned with managing the knowledge that they need to successfully achieve organizational objectives. This need has fostered the creation of the rapidly evolving discipline of knowledge management (KM). The general tools and techniques developed by the leaders in the KM field are applicable to the specific needs of organizations interested in PK management. Therefore, the initial activity in this work was a survey of the general field of KM, with the goal identifying KM strategies that can be implemented by D&D IPTs to manage the acquisition of PK.

Next, Lines of Inquiry (LOI) were developed to assess how various organizations in the DOE complex acquire and use PK for D&D projects. These LOI were sent via email to several DOE sites. Responses were received from Hanford, the Savannah River Site (SRS) and the Paducah gaseous diffusion plant. Telephone discussions were initiated with personnel at Sandia National Lab (SNL), Lawrence Livermore National Lab (LLNL), and the East Tennessee Technology Park. LLNL and SNL provided electronic copies of the documents that control their historical information gathering process. SNL was also visited to discuss its exceptional PK management program in greater detail.

Finally, the PK management practices of the Department of Defense and the commercial nuclear industry that are potentially relevant to D&D of DOE facilities were surveyed. A literature search of US Army Corps of Engineers (USACE) publications was performed to identify USACE experience in this area. The Electric Power Research Institute (EPRI), which conducts research and development for the global electricity sector, recognizes that PK management is a significant issue in all phases of the nuclear power plant life cycle, including decommissioning. Several EPRI documents which address the issue of PK management were reviewed.

2.3 SCOPE AND APPLICABILITY

This document provides DOE personnel and contractors with non-mandatory guidance on the nature and scope of the PK that is desirable to assemble for efficient and effective conduct of a facility D&D project. Anticipated users of this guidance include:

- D&D contractors who may have limited experience in the process design, construction and operation of the kinds of facilities typically found at DOE sites. These contractors may also have limited knowledge of the kinds of administrative and document repository systems typically in place at DOE sites. Such administrative systems require that certain types of documents (design drawings, equipment information provided by vendors, incident reports, etc.) be prepared, maintained current, and stored for retrieval as needed.
- Personnel familiar with operations at DOE facilities, but who have limited experience in conducting D&D projects. There are two types of these potential users:

  - Personnel with an operations background who have been assigned to a D&D IPT. This situation occurs frequently in the DOE complex as operations continue to wind down at the various sites and operations personnel are re-assigned to other work, such as D&D. These users will find the suggestions of what constitutes good PK and where to find it helpful.
  - Operations personnel at a facility which is at the end of the operations life cycle phase and is beginning planning for transition to long term S&M or directly to D&D. Information is provided to these users to help them understand what data are useful to the D&D IPT that will eventually inherit the facility. These users may be responsible for assembling a PK package for the facility. Such packages may be archived during the extended S&M period for retrieval when needed. Since the experienced personnel who operated the facility may disappear during the S&M period, it is important that such package preparers understand the PK needs of the D&D IPTs that will eventually use them.

- Personnel who are responsible to independently review a facility D&D project to determine whether the IPT has obtained the appropriate level of PK about the facility to support the various D&D planning functions (i.e. waste characterization, worker exposure to hazardous materials, equipment removal, etc.).

2.4 KNOWLEDGE MANAGEMENT CONCEPTS

Although there is no universally accepted definition of KM, it is generally agreed that KM is the creation, capture, storage, availability and utilization of information, knowledge, and experience [1]. EPRI reviewed then-current KM practices with the objective of developing methods for capturing high-value undocumented knowledge in the nuclear power industry. EPRI concluded that methods and technology are available to help nuclear power operators retrieve, present and store valuable undocumented knowledge for future use [1]. These methods are also available to D&D IPTs for use in gathering the knowledge needed for safe and effective D&D of DOE facilities.

2.4.1 Explicit Knowledge

All knowledge is either explicit or tacit. Explicit knowledge is the type of knowledge which can be recorded in familiar documents such as drawings, specifications, reports and manuals. Explicit knowledge may or not have yet been recorded. Explicit knowledge is distinguished from tacit knowledge by the fact that it is defined to the extent that it could be documented, although it may not yet have been. Undocumented explicit knowledge is in the minds of people. Once extracted, it is easily documented [1].

2.4.2 Tacit Knowledge

Tacit knowledge only exists in the minds of people. By definition it is undocumented. In some situations people possessing tacit knowledge may not even be aware of its importance or value. Tacit knowledge is valuable if its application to a relevant activity results in the activity being executed in a safer or more efficient and effective manner than if the knowledge were not applied. Tacit knowledge may not be valuable if its application has limited or no positive impact on the activity to which it is applied. There is much tacit knowledge that is not valuable and not therefore worth capturing [1].

Among other names, tacit knowledge is also known as tribal or hidden knowledge. EPRI identified a type of tacit knowledge that relates to what it calls corporate history [1]. People who have been in an organization for many years have been exposed to key events, informal notes, documents and records and other people. They often have valuable knowledge in their heads or know where it might be found, whether it be in physical repositories or in the minds of others. These knowledgeable people are aware of the rationale behind specifications, procedures, designs and processes because they were there when these things were created or introduced [1]. Such knowledge may be relevant to D&D efforts and is therefore worth extracting or eliciting.

2.4.3 Tacit Knowledge Elicitation

Valuable undocumented knowledge consists mainly of tacit knowledge but it may also involve explicit knowledge. Following elicitation, tacit knowledge becomes explicit. The process of extracting tacit knowledge from people is known as eliciting or harvesting the knowledge [2]. Tacit knowledge is made explicit by elicitation. EPRI suggests several methods for capturing and transforming elicited knowledge into a usable form [1]. Interview methods are perhaps the most familiar.

The following sequence of knowledge elicitation has been proposed [2]:

Focus: Determine what knowledge is being sought. Choose the appropriate strategies and techniques for eliciting the knowledge. Identify the target audience for the knowledge to be elicited and its specific needs (see Table 1, for example).

Find: Find the experts whose knowledge is being sought and prepare to interview them by studying existing documentation that is relevant to the information being sought.

Elicit: Interview the experts. This is the key event in the elicitation process. Preferably it should be performed by someone with at least some training in knowledge harvesting. The elicitation goal is to fill gaps in the existing knowledge about the subject being investigated. A comprehensive interview requires significant effort by the elicitor before and after the actual interview. After the interview, the interviewer must then compare the information elicited with the needs of the users to verify that knowledge gaps have been closed as much as practical. Multiple iterations through the whole process may be necessary for maximum benefit.

Organize: Appropriately categorize the resulting information.

Package: Publish the knowledge in an electronic repository available to those who need it.

EPRI concluded that the most valuable tacit knowledge is often difficult to elicit [1]. Trained elicitors may be required. EPRI also noted that elicited knowledge from an expert should be considered invalid and should not be used by others until it is validated by appropriate personnel and approved as accurate and, therefore usable. Selection of knowledge elicitation

Table 1 PK Users, their Roles and Needs

PK User	Role	Process Knowledge Needs
D&D Engineer	Provide technical input to work control documents that govern the safe isolation, draining and/or venting, dismantlement, removal and disposal of process equipment	What materials were processed in the equipment that might still be present and must be removed and dispositioned Materials of construction. Needed to specify removal and size reduction approach Weight and size needed for rigging and transport out of facility Tank and associated piping configuration needed to identify low point drain and line cut locations (for both draining and removal) Electrical and piping connections with other facilities that need to be broken to make the facility cold and dark prior to D&D
Waste Characterization personnel	Characterize waste sufficiently to meet waste acceptance criteria at planned treatment, disposal and storage facility (TSDF)	What materials were processed in the equipment that might still be present Materials of construction. Needed to make hazardous waste determination
Waste management personnel	Package waste and arrange for transport to the appropriate TSDF	What materials were processed in the equipment that might still be present Materials of construction. Needed to make hazardous waste determination
Environmental Compliance personnel	Ensure that all regulatory issues are addressed (e.g. National Environmental Policy Act, Comprehensive Environmental Response, Compensation and Liability Act [CERCLA] and RCRA)	What materials were processed in the equipment that might have already escaped or could escape to the environment during D&D

methods is based on several factors, including the nature of expert and the background of the elicitor.

Advance preparation increases the effectiveness of knowledge elicitation sessions. Make procedures, maps, photos and drawings available at the interview to aid the expert being interviewed to recall valuable information. The elicitor should be as knowledgeable as possible of the subject of the interview [3].

2.4.4 Knowledge Elicitation Methods

2.4.4.1 Critical Decision Method

This method is an incident-based technique. A challenging incident is elicited from the expert. The elicitor leads the expert through the incident chronology. A basic record of what happened, at what point in time, at what location within the system is created. This method may yield useful information about problems and incidents that occurred at each location and steps taken to correct the problem [3]. In the context of D&D, it may reveal undocumented incidents, (e.g. a major spill) and the action taken in response, (e.g. installing a steel liner or several inches of poured concrete over the resulting contamination). Without this knowledge, the D&D IPT would encounter surprises during D&D, resulting in schedule delays, increased costs and potential safety concerns.

2.4.4.2 Interview Methods

Interview methods are used alone or in combination with other methods and techniques to elicit valuable knowledge from experts. Many elicitors naturally use interview methods as an obvious way to obtain information. A dialogue is created with an expert. Questions are asked and answers recorded. Interviews can be structured or unstructured. Unstructured interviews usually involve a dialogue between the knowledge elicitor and the expert. The elicitor asks open-ended questions about the expert's knowledge. As the interview progresses, the elicitor adds more structure. The results obtained from an unstructured interview lead to a follow-up structured interview. Interviews require that the expert's responses to questions be recorded. This is done by note taking or audio/video recording. The problems identified with unstructured interviews include loss of focus by the expert and elicitor inadequate technical knowledge [3]. This latter problem prevents the interviewer from fully appreciating the expert's comments, resulting in missed opportunities for follow up questions which elicit valuable information.

Interviews with current or previous employees are performed to collect first-hand information about the site or facility and to verify or clarify information gathered from existing records. Conduct interviews to collect general site or facility information early in the data-gathering process. Use results of early interviews to guide subsequent data collection activities [4].

Interviews scheduled late in the data gathering process are especially useful. They allow questions to be directed to specific areas of the investigation that need additional information or clarification. Photographs and sketches are used to assist the interviewer and allow the interviewees to recall information of interest. Conduct interviews at the interviewee's work

site to jog their memory and facilitate information gathering. In addition to managers, engineers, and facility workers, interview other support personnel, such as vendors and contractors to obtain information from their perspective. Be cautious in the use of interview information. It must be assessed for accuracy. Interview results should be backed up with supporting data. To ensure specific information is properly documented, consider hiring trained investigators and taking affidavits [5].

2.5 DEFINITION OF PROCESS KNOWLEDGE FOR D&D

In the context of D&D, what is meant by the term "process knowledge"? The use of the term in the chemical process industry is not uniform. Moreover, the United States Environmental Protection Agency (USEPA) uses the term in the context of waste characterization for compliance with the Resource Conservation and Recovery Act (RCRA). Since D&D activities generate waste which may be subject to RCRA, the D&D operational definition must encompass the scope of the USEPA definition. However, this definition must serve the needs of other D&D IPT members, such as D&D engineers, work planners, waste generators (D&D workers performing the dismantlement and removal of equipment), waste characterization and waste management personnel.

USEPA offers the following guidance for waste generators:

> The cornerstone of the RCRA program, and the focus of this guidance manual, is the ability of facility personnel to identify properly, through waste analysis, all wastes that they generate, treat, store, or dispose of. Waste analysis involves identifying or verifying the chemical and physical characteristics of a waste by performing a detailed chemical and physical analysis of a representative sample of the waste or, in certain cases, by applying acceptable knowledge of the waste (acceptable knowledge includes process knowledge …..You must conduct proper waste analysis to determine whether your waste is defined as a hazardous waste under RCRA, to identify/classify the waste according to RCRA, and to ensure that your waste is managed properly. How your hazardous waste is classified under RCRA will determine the legal methods available to you for treatment, storage, or disposal of the waste. Waste analysis, therefore, is the pivotal activity that you must conduct properly to ensure that your facility is in compliance with the myriad applicable regulations for proper waste treatment, storage, or disposal [6].

In the same document, USEPA goes on to say:

> Acceptable knowledge can be used to meet all or part of the waste analysis requirements. Acceptable knowledge can be broadly defined to include:
>
> "Process knowledge," whereby detailed information on the wastes is obtained from existing published or documented waste analysis data or studies conducted on hazardous wastes generated by processes similar to that which generated the waste.

Therefore, from USEPA's perspective, PK can be seen as an acceptable alternative to expensive and time-consuming laboratory analysis when characterizing waste. Of course, the PK data used in waste characterization must be defensible and the burden of proof lies with the generator when using PK to characterize waste.

As can be seen, the USEPA definition of PK focuses on the information needed for waste disposal. This is only a subset of knowledge needed about a process to effectively perform D&D. Therefore, the following operational definition of PK for D&D is offered:

Process knowledge is that body of technical information about each process in a facility that will allow that process to be safely deactivated, its equipment decontaminated of residual process material (if required) and dispositioned in a manner to meet the final decommissioning end points.

Note that this definition goes beyond the information needed for waste characterization and includes the engineering information to deactivate the facility and prepare it for final decommissioning (by demolition or in situ disposal). Process history (PH) is sometimes mistakenly used as a synonym for PK. It is clear from the above definition that PK encompasses a significantly greater body of knowledge than PH. PH is limited to the record of past production operations in a facility, including types of materials processed in various campaigns, material control and accountability (MC&A) records, spill and release records, incident reports, raw material use records, and waste characterization/disposal records. This information is necessary for D&D, but not sufficient. The engineering information that defines the facility design, construction and current configuration is needed to form the complete body of knowledge sufficient for facility D&D.

3.0 SURVEY OF CURRENT PK MANAGEMENT PRACTICES IN THE NUCLEAR INDUSTRY

All segments of the nuclear industry are confronted with the common need to decommission contaminated excess facilities. D&D PK management practices within DOE, the commercial nuclear industry and the Department of Defense were examined. The results are summarized as follows.

3.1 NATIONAL LABORATORIES

In response to telephone requests for information on their D&D PK management practices, both SNL and LLNL provided documents that describe their excellent PH data gathering programs. Since they provided these documents, it was not necessary for them to formally respond to the LOI discussed in section 3.2. The data gathering approach taken by SNL and LLNL as described in the provided documents is detailed below.

3.1.1 PH Data Gathering at SNL

SNL has an active D&D program. Since the site has enduring missions, the focus of the D&D program is on space recovery, as opposed to area or site closure. SNL uses a tailored approach when conducting assessments of facilities planned for D&D. Accordingly, such facilities are categorized into the following areas [7]:

1. Administrative/office
2. Computer laboratory
3. Light laboratory
4. Radiological/chemical work area
5. Chemical/radiological storage
6. Non-chemical, non-radiological storage

The above areas are also categorized by radioactive materials management area (RMMA) status.

When a facility is designated for D&D a contamination assessment is conducted. This assessment consists of a determination of the level of detail needed to document the current and historical uses of the building. A site information audit as described below may be performed to determine the potential for contamination at the facility and to inform the remainder of the contamination assessment [7].

3.1.1.1 Site Information Audit

When conducting the site information audit, the following information is obtained and reviewed:

- Building plans
- Structural and equipment specifications
- Operations logs

- Records indicating materials used or processed in the facility
- Records of types of activities performed in the building and chronology of these activities

Interviews with knowledgeable personnel are conducted to gather additional information. Questionnaires are used to ensure thoroughness and consistency. Questions seek to reveal information on the types, locations and uses of hazardous and radioactive materials in the building. Completed questionnaires and other relevant information are compiled into site history documentation and used to direct the subsequent site inspection [7].

3.1.1.2 Site Inspection

A site inspection is conducted at the facility to verify the information audit results and to provide additional contamination information if needed. Due to the variety of potential contaminants present at SNL sites, inspections may require the use of a multidisciplinary inspection team. The team may consist of subject matter experts in the areas of industrial hygiene, health physics, environmental regulations and D&D activities. Facility inspection checklists are used to ensure that areas of concern are thoroughly investigated and properly documented. Each area of confirmed or suspected contamination is documented on the inspection checklist and associated building layout drawing along with a brief description of the suspected contamination [7].

3.1.1.3 Site Audit Report

At the conclusion of the assessment phase, SNL prepares a Site Audit Report summarizing the information gathered. The report contains the following information [7]:

- A description of the facility, including layout, type of construction, RMMA status, building classification (i.e. one the six described in section 3.1.1) and activities conducted at the facility
- A layout of the facility showing areas of actual and potential contamination
- A summary of
  - the site information audit and inspections, including methodology and results of the audit
  - information gathered from interviews, database searches, and historic record searches
  - sampling and analysis activities, if any, carried out at the facility and their results with a list of items and areas of each structure identified as contaminated or requiring additional investigation or special handling.
- A recommendation for one of the following
  1. If the existing information is complete, of adequate quality, and chemical and radioactive contamination is ruled out, then the evaluation process is complete. Proceed with demolition.
  2. If there is contamination, the information is adequate and of sufficient quality to determine its nature and extent, then the evaluation process is complete. Proceed with decontamination.
  3. If more information is required, then sampling and analyses must be performed. The site audit report recommends the extent of sampling and analyses needed to characterize the facility.

3.1.1.4 Assessment Review

Appropriate subject matter experts evaluate the information obtained during the information audit to determine its completeness and reliability. The information is considered complete if [7]:

- Information is available for all the years during which the facility was operational.
- The building construction is standard and disposal pathways for the building materials are available.
- Any releases of hazardous or radioactive materials are fully characterized and documented.
- The methods used to obtain chemical and/or radiological data were standard, verified, methods, accepted by regulatory authorities.
- The information was provided by persons who held positions of responsibility at the facility and whose knowledge of the activities at the facility should be reliable.
- The information is consistent.

3.1.2 PH Gathering at LLNL

LLNL has an excellent process history gathering program. LLNL uses what they call the Space Action Team (SAT) to prepare for the demolition of excess facility space. The Historic Information Manager (HIM), a member of the SAT, is responsible for gathering, organizing and disseminating data related to the demolition of excess facilities.

3.1.2.1 LLNL Data Gathering Overview

In order to ensure consistency, LLNL created a document to control the D&D data gathering process. The purposes of this document are to [8]:

- Identify the data to gather; then organize and disseminate it to support facility demolition
- Document that hazards identification was diligently performed
- Document the locations where the historical information resides
- Identify the lessons learned that can be applied to future facilities and follow the LLNL project information closeout process to archive project information

Data useful for D&D is gathered from the following information sources:

1. Building financial history files
2. Historical site plans, maintained in electronic format
3. The Facility Information Management System (FIMS) database, which can provide a record of the historical ownership of facilities, site approval documents, and facility siting requirements. FIMS may provide a record of when the facility was first used or occupied.
4. Fire Department files
5. Hazards Control Department files
6. Occurrence Reports
7. Incident Analyses

8. Site asbestos database, where suspected asbestos location data are stored. Although considered for "Informational Use Only", the database provides a starting point for final characterization.
9. High-Efficiency Particulate Air Filter database
10. Condition Assessment surveys
11. Key plans (floor plans with supplemental sheets containing facility interior space data)
12. Site maps (provide valuable facility location and relocation information)
13. The Master Equipment List (see section 4.1.1.5)
14. Records Management files
15. Hazards Control Department screening reports and Facility Hazards Category (Office, Light Science & Industry, Low hazard, Moderate hazard, and High hazard)
16. Environmental information, including information on radioactive and hazardous waste provided by the Environmental Protection Department
    - Facility drain reports
    - Environmental Restoration Division subsurface information
    - Operations and Regulatory Affairs Division (ORAD) files
    - ORAD's Environmental Operations Group spill reports
    - Environmental permits
    - Storm Water Pollution Prevention Plan
    - Retention tank reports
    - National Environmental Policy Act and National Historic Preservation Act documents
    - Inventory of hazardous materials assigned to the facility

3.1.2.2 Personnel Interviews

LLNL identified personnel interviews as an important source of facility hazard identification information. The SAT HIM is responsible for the interview process and its implementation. LLNL uses the following general guidelines for the interview process:

1. Develop good relations with all potential interviewees. Treat all with dignity and respect. Make friends with interviewees since they may be needed again for other facilities. Be someone who can be trusted.
2. Pursue retirees persistently, but politely, to learn what they know.
3. Locate retirees using property records at the appropriate county office, if need be.
4. Contact all people who may have valuable knowledge even though they may have hard feelings toward the site.
5. Provide the appropriate identification (e.g. site security badge) to reassure the interviewee that the interview is official site business.
6. Conclude that enough interviews have been done when no new information is forthcoming.
7. Know when to be quiet and listen.
8. Be willing to go wherever it is convenient for the interviewee.

9. Conduct phone interviews if travel funds are not available for face-to-face interviews. Email the questions and related interview material prior to calling.
10. Ask to be contacted if the interviewee thinks of anything else later.
11. Ask leading questions, and then be quiet and listen.
12. Record information legibly, even if it slows the pace of the interview. At the end of the interview, review the interviewee's responses to make sure the information is captured correctly.

The major steps in the LLNL interview process are listed below.

3.1.2.3 Development of Interview Materials

In order to make the most efficient use of resources and be respectful of an interviewee's time, it is critical that the interviewer properly prepares for each interview. It is important that the interviewer knows all of the identification numbers that the facility has been known by over its life. All interview materials are placed in a 3-ring binder to take to the interview. The content of the binder includes:

1. A set of key facility plans. Multiple copies are required so that interviewees can mark directly on the key plans, identifying areas of concern and possible contamination.
2. A list of typical contaminants, which may jog the interviewee's memory.
3. A set of exterior and interior facility photos, which the interviewee can then mark up as needed
4. An interview planning sheet, with the interviewee's personal information and open ended questions to ask regarding potential facility hazards.

3.1.2.4 Identification of Interviewees

The LLNL HIM determines the number of interviews that may be appropriate for the facility, considering complexity, size, age, types of contamination, and existing documentation. The HIM obtains the following information from and about the interviewee:

- Contact information including date and time contacted
- List of facilities of which he or she is knowledgeable

The Hazard Control group most familiar with the facility is interviewed first. This interview may identify others who have personal knowledge of potential facility hazards. Additional interviews with on-site personnel and retirees may be necessary. If the interviewee suggests the names of others who may be knowledgeable, contact information is obtained for follow-up. The following questions are asked to obtain information about the additional knowledgeable people:

- Are they still on site?
- Do you know where they live or lived?
- Do they still work here part time?
- If retired, did they move out of state?
- Are there others who might know where they are?

3.1.2.5 Conduct of Interviews

LLNL has learned from experience that conducting interviews is both an art and skill, requiring development. Interviewers demonstrate appreciation of the fact that the interviewee is willing to share information. They recognize that opinions formed early in the interview process will impact the success of the interview. Interviewers try to demonstrate that they value the knowledge, experience and information possessed by the interviewee. They try to be on time and respectful of the interviewee's time. Interviewers are organized and prepared for the interview. They listen, listen, listen and then ask leading, open ended follow-on questions. Interviewers come to the interview with knowledge of the facility, after having taken photos and researched facility history. They bring felt tip pens for use by the interviewees so that documents can be directly marked up. If possible, an interview assistant also attends to record interviewee responses, thus allowing the interviewer to focus on the interview, rather than recording information.

3.1.2.6 Compilation of the Interview Results

All interview documents are placed in a tabbed binder as soon as they are completed. LLNL has found that these documents are some of the most difficult to acquire and some of the most valuable to have. If needed, follow-up is scheduled as soon as possible.

3.1.2.7 Development of a Hazard Map

Hazard maps, which present all the hazards identified during the above data gathering process, are prepared. The threefold purpose of these maps is to:

1. Present to facility demolition workers the hazards associated with each room or area
2. Provide the basis for a more focused sampling plan
3. Demonstrate due diligence in hazard identification

Development of the facility hazard map starts on completion of the historical research and organization of the information into binders. After the SAT leader identifies a need for a hazard map, the data gathered in the historical information process is then quality checked as follows:

1. The SAT HIM reviews the binders and identifies the facility hazards potentially encountered during facility demolition.
2. The HIM identifies each potential hazard, (e.g. asbestos contamination) and its location in the facility and marks it on a facility map.
3. These mark-ups are then given to a designer, who creates an electronic copy using a Computer Aided Design (CAD) software package. The CAD drawings are then reviewed with the HIM, and the hazard map is modified as needed.
4. The CAD drawing is then reviewed by the SAT leader and project manager.
5. The map is modified if needed, saved as a PDF file, and posted to a server accessible to the project manager
6. The project manager typically distributes the hazard map and posts hard copies in the facility to be demolished.
7. The designer then gives a final revised copy to the HIM, who passes it on to the LLNL archivist after project completion.

3.2 DOE SITES WHICH RESPONDED TO LOI

Several sites did not provide any documents which describe their PK gathering process, but did respond to the LOI which they received (see section 2.2). The responding sites were Hanford, Paducah and SRS. The responses are summarized in Table 2.

3.2.1 Paducah Gaseous Diffusion Plant (PGDP) Background Information

Since the PGDP is somewhat unique in the DOE complex, the following information is provided by Jon Rodabaugh of NuVision Engineering, as background to help understand their response to the LOI. The PGDP is a DOE facility that is currently leased from the government and operated by the United States Enrichment Corporation (USEC). USEC has no responsibility for either D&D or Environmental Remediation activities at the Paducah site. DOE has contracted with Paducah Remediation Services, LLC for D&D and environmental management services at the Paducah facility. One major and multiple smaller D&D projects are currently underway. The major D&D project is the cleanup and demolition of the original process feed plant which produced uranium feedstock for the gaseous diffusion process. This facility halted operation about 30 years ago and accumulated a huge inventory of stored material not native to the feed plant.

USEC maintains fully operational document and drawing control, record storage, and information management services to support the ongoing operations. These resources and services are available to the D&D contractor. Facility drawings or inventory records were typically not updated after the facility was shut down. No record of equipment removed from the facility was maintained, nor was a record kept of material moved into the building for storage.

Many of the shutdown facilities process operations staff are either employed by USEC, or are available as consultants through a local engineering services contractor. The D&D contractor has determined that consulting with employees of the entire gaseous diffusion facility will be valuable for identifying material that did not originate within the facility.

The need for process knowledge collection and documentation was not acted upon until the feed plant had been idle for about twenty years. A contractor was hired to contact former facility workers and document their recollection of the facility operation and final shutdown process. Facility walkdowns with former workers were useful in obtaining relevant operating history, identification of special projects conducted in the facility after shutdown, and identification of stored material not of the facility. This information was documented in final reports and was useful in scoping and planning the D&D activities.

At Paducah, the facility operating records were treated as classified, restricted access information. With the abandonment of the feed plant, the feed plant operating records were hurriedly secured, without filing or cataloging, when the facility became unoccupied. The large physical volume of these records, their security classification, and the access restrictions to this information make it impractical to utilize this information for D&D

planning. Simply cataloging the contents of the files would have made this resource available.

Table 2 Response of SRS, Paducah and Hanford to LOI

Lines of Inquiry	SRS Response	Paducah Response	Hanford Response
Capture of info needed for equipment removal and waste disposal. Do you use any of the following?			
Master Equipment List (MEL)	If available, these are used. Usually not available for older facilities.	No MEL – but extensive inventory developed by subcontractor identifying key equipment and potential RCRA & Toxic Substances Control Act (TSCA) compliance issues, volume and mass estimates, location, etc.	Many of these lists and documents are used during D&D planning. Many times these lists are not required because they are too detailed (e.g. a listing of every value usually isn't necessary except for rare occasions). These lists can be helpful to identify building utility systems, process systems, equipment systems, etc. These lists typically do not help in determining waste streams, segregation requirements, D&D sequencing, demolition equipment requirements, etc.
Instrument List	Not usually	No	
Line List	These are sometimes helpful. Not usually up to date.	No	
Procurement specifications	Sometimes used for complex equipment. Sometimes available for older facilities.	Yes, use design specifications for identifying prohibited and regulated materials	
System Design Description (SDD)	Not usually available.	Yes – see above	
Valve List	Not typically used.	No	
Vendor Print Files	Frequently used for complex equipment removal and disposal	No	
Vendor Technical Manuals	Not often available, but can be helpful	No	
Operator training manuals	Very helpful.	Yes. Operating manuals and procedures are useful for listed waste determinations (e.g., applicability of manufacturing process unit exclusion to the Contained in Policy for listed).	
As-built drawings providing installation details	Usually available, but not completely accurate for older facilities.	Yes	As-built drawings do not always exist and when they do they may be inaccurate as a result of undocumented renovations or other reasons. Therefore, it is necessary that the structure be inspected prior to demolition planning. If the as-built drawings are found to be accurate, information can be collected from them. Information available from
– P&ID	Very helpful	Yes	
– Equipment arrangements	Very helpful	Yes	
– Electrical	Good for electrical isolation in assuring the facility to be	Yes, contains useful information on RCRA and TSCA regulated debris	

Lines of Inquiry	SRS Response	Paducah Response	Hanford Response
	decommissioned is "cold and dark".		as-builts would consist of material quantities and types, waste quantities, and other issues. Drawings also help to determine demolition sequencing, structural evaluations, hazardous material locations, utility isolation locations, etc. As-built drawings assist in the location of underground utilities and infrastructure.
– Architectural	Sometimes useful info can be gleaned from these.	Yes	
– Building plan	Very helpful	Yes	
– Fire system	Useful for developing pipe tap and drain plans	Yes	
– Process flow sheets	Very helpful if available. These were not typically kept up to date	Yes	
– Floor drains	Very, very helpful. All floor drains are typically plugged.	Yes	
– Piping arrangements	Not as helpful as P&IDs.	Yes	
– Heating, Ventilation and Air Conditioning (HVAC) system	Used frequently. All potentially contaminated exhaust system duct is removed prior to demo. Supply duct (usually clean) is left in place for building demo.	Yes	
– Structural	Frequently used for structural analysis	Yes	
Removal and disposal of residual process material from equipment			Removal and disposal of residual process materials is determined on a case by case basis. Materials are identified through PK and site inspection. PK is more reliable on systems that were recently deactivated and less reliable on abandoned systems. All systems are inspected to verify if material is present (on occasion, conducting ultrasonic tests or hot tapping the system is required). Based on the extent and validity of existing information, additional characterization or confirmation sampling and analysis may be necessary. Additional characterization may be required by Regulatory documents and for waste disposition purposes. Based on the type
How do you identify actual or potential liquid content of items (vessels, piping, sumps, etc.)?	All vessels are visually inspected. Cameras are sometimes used if needed to for thorough inspection.	Visual inspection and PK (no real time radiography, infrared imaging, etc.)	
To what extent do you rely on PK for characterization?	Small amounts of liquids are absorbed with drying/neutralizing products. PK is used to characterize resulting solids.	PK is used for listed waste determinations, situations where a false positive determination does not increase disposal costs (we avoid PK where a false negative would result in a non-compliance).	

Lines of Inquiry	SRS Response	Paducah Response	Hanford Response
			and quantity of material, removal and disposal options are evaluated. Evaluation criteria include material type (liquid, sludge, solid), radiological contaminates, hazardous material contaminates, waste disposal alternatives, available technology, cost, schedule, DOE and regulatory requirements, etc.
To what extent do you rely on sampling for characterization?	Large volumes of liquid that must be removed from systems are typically sampled.	All liquid and granular/volumetrically-contaminated waste receives some degree of sampling and analysis. Debris is only sampled under special circumstances (e.g., oil-stained debris where dielectric fluid is known to exist would be sampled by hexane wipe for PCBs, applied dry paint is sampled for PCBs to establish baseline data which is later used as process knowledge).	
How do determine if vessels, basins, sumps, etc. have sludge?	All vessels are visually inspected. Cameras are sometimes used if needed to for thorough inspection.	Visual observation or sample collection. Sludge is differentiated from environmental media based on source of particulate material.	
How do you determine if sludge needs to be removed?	Sludge is usually removed, unless there is some special circumstances that would justify not removing.	Generally, all sludge is removed, even if the structure or devices is being grouted.	
How do you determine if sludge needs to be stabilized?	SRS experience has shown RCRA metals are a concern in sludge. Sludge is always sampled for these and other COCs as guided by PK. Stabilization strategy is determined based on sample results.	The principle driver for stabilization is RCRA/TSCA characterization. We don't land-farm. TSCA and listed waste sludge is treated by incineration and vacuum thermal desorption. Essentially, all sludge is stabilized, either to remove RCRA characteristics or eliminate free liquid.	
Do you do in situ stabilization?	Small amounts of sludge that has been characterized as non-hazardous may be stabilized in situ by	Generally don't treat waste on site. Waste might be stabilized in situ to reduce occupational exposure.	

Lines of Inquiry	SRS Response	Paducah Response	Hanford Response
	grouting.		
Do you stabilize sludge after removal?	If non-hazardous, add drying agent dispose as sanitary of low level waste as appropriate.	Most common – send off site for stabilization at TSDF.	
How do you characterize sludge?	Primarily by sampling and analysis	Primarily by sampling and analysis	
To what extent do you rely on PK for characterization?	To identify the requested COCs for analysis. It is not cost effective to analyze for every thing.	PK is used for Listed Waste Determinations (e.g., source or initial concentration of contaminant).	
To what extent do you rely on sampling for sludge characterization?	All significant quantities of sludge are sampled	Sampling is the primary source for sludge characterization.	
Do you visually inspect vessels, basins, sumps, ducts, piping, etc. for free and attached dry solids?	Yes	Yes	
Do they need to be characterized to meet TSDF WAC or can you dispose as found?	Dry solids are always characterized. PK is used to determine if sampling to scale is justified.	Require characterization	
To what extent do you rely on PK for characterization?	See above.	PK is used for Listed waste determinations and for concentration averaging.	
To what extent do you rely on sampling for characterization?	See above.	Characteristics of free particulate and attached scale are determined by sampling.	
Characterization of equipment components for disposal			Equipment disposal usually is dictated by the type of material it processed and will follow the same waste disposal path. Equipment sometimes can be efficiently decontaminated to allow for a less costly disposal.
To what extent do you rely on PK for equipment characterization?	PK is used extensively for equipment items	PK is frequently used to characterize debris.	
To what extent do you rely on sampling for characterization?	Only a small fraction of equipment is sampled.	Free liquids are sampled. Oil stains are sampled for PCBs (hexane wipes)	
To what extent do you rely on PK for characterization of structural components to be disposed in situ?	PK is used to limit the COCs to what may reasonably be expected.	This implies closure. We don't rely on PK to characterize for closure.	Structural disposal usually is dictated by the type of equipment and material it housed and will follow the same waste disposal path. Structural components sometimes can be efficiently decontaminated to allow for a less costly disposal. Structural disposal is typically documented in regulatory
To what extent do you rely on sampling for characterization of structural components to be disposed in situ?	Extensive sampling is performed as part of the final verification survey.	Samples and direct radiation survey used in accordance with closure plans.	
To what extent do you rely on PK for characterization of building debris to be	Trained asbestos workers identify and sample all potential asbestos	PK is used for positive determinations on likely materials (e.g., transite is	

Lines of Inquiry	SRS Response	Paducah Response	Hanford Response
sent to the TSDF?	containing material. Site records indicate where PCB-containing paint was used.	presumed to contain asbestos, debris with applied, dry paint is presumed to be PCB bulk product waste if PK indicates such).	documents.
To what extent do you rely on sampling for characterization of building debris to be sent to the TSDF?	All pre-1978 buildings are surveyed via handheld XRF gun for lead-based paint, so that debris can be properly characterized. Sampling building materials is rarely done.	Samples are always used when a false negative would result in non-compliance activities.	
To what extent do you rely on PK for characterization of Job Control waste?	Smear-to-curie methods are usually used, where waste weight and surface contamination are used to calculate its curie content. Room radiological posting can be used as worst case contamination.	Job control waste is nearly always characterized by PK.	Waste is characterized by a combination of PK and sampling. PK will be used to help establish the extent of analysis (rad, heavy metals, hydrocarbons, etc.) that will be performed.
To what extent do you rely on sampling for characterization of Job Control waste?		Seldom	
Work planning for equipment removal and disposal: Do you use PK to estimate weight and/or stability for rigging?	Site drawings and vendor documentation is reviewed by engineering if this information is needed.	Safety does this	Information for work planning is captured through a variety of methods including PK, sampling, site drawings, site inspections, etc. Usually additional sampling or radiological surveying is required. Each aspect of the project is thoroughly evaluated to identify hazards ranging from hazardous energy to radiological to industrial safety. These are captured and documented in the work planning process.
Work planning: Industrial Hygiene - non-radiological materials (acid, base, flammable/explosive)	PK is used to identify chemicals that workers may be exposed to.	Material Safety Data Sheets, pH strips, pH meters, photo ionization detectors and flame ionization detectors	
– Lead	PK and sampling are used for worker protection planning.	Lead test swabs	
– Asbestos	Sampling is primary method of characterization.	PK, asbestos professionals and bulk samples	
– Biological	Sampling is primary method of characterization.		
– Mold			
– Animal waste			
Work Planning: hazardous energy control			
– Pressure	PK is used to identify systems that may be pressurized.		
– Electrical	Design drawings are used to identify systems that need to be energized through the cold and dark process.		

Lines of Inquiry	SRS Response	Paducah Response	Hanford Response
Work planning: Radiological Control	Historical radiological control records and new surveys used to fully understand radiological hazards.	Radiochemical analysis of samples (Radiological Control Inspectors conduct direct surveys)	
Work planning: criticality control	Historical records (such as MC&A inventories are used to evaluate criticality potential.	Assay wipes, radiochemical analysis of samples	
– Is PK sufficiently bounding for characterization?	No	No	
– Is sampling/survey needed for proper characterization?	Yes	Yes	
How do you capture the information needed for execution strategy?	Document review		Based on the scope of work and the identified hazards, the execution strategy is prepared. Depending on the complexity of the project, the strategy is documented in the Project Execution Plan (PEP). Usually the PEP is a strategic level document that is supported by more detailed documents that specifically identify project tasks (e.g. structural demolition sequence and requirements plan, engineering studies, etc.). These tasks may or may not have specific plans developed depending on the complexity or hazards associated with the tasks. Tasks typically will have their own work package detailing the scope of work, associated hazards, and hazard controls. The tasks are scheduled in detail to identify specific steps.
– Engineering			
– Structural			
– Mechanical			
– Electrical			
– Environmental			
– Rigging			
– Project Management			
– D&D worker			
Process history: Did your site issue regular periodic production reports which might indicate types and quantities of materials produced in various facilities throughout their history?	Yes	Yes	Some reports are still classified and therefore not available. Some general information may be available from other sources or declassified reports. Usually the general process, types of

Lines of Inquiry	SRS Response	Paducah Response	Hanford Response
			chemicals used or waste streams are available.
If so, do you use these to obtain process history?	Surprisingly hard to find.	Infrequently – information difficult to recover	All available information is evaluated during the initial planning of the project and preparation of regulatory documents.
Do you have a searchable Records Management or Document control function?	Yes	Yes – but the inventory of older (pre-2002) records is not complete.	Yes
Describe how you use it to obtain process history	We can search by building number and project number. Once you find a useful document (drawing, etc., it usually refers you to others. Keep pulling the string.	Key word searches	
Describe how you use DOE mandated Occurrence Reporting System to obtain process history	Database searched by facility number is performed for all process buildings.	I am not performing this function.	Evaluated for spill information
Do you have any other spill or environmental release reporting system?	Yes. A local system was in place prior to ORPS. It is searched also.	None that I use	Existing spill / release reporting system is used as necessary.
Do you have a chemical purchase and tracking system that recorded material that entered each facility?	Yes. This is sometimes, but not always, used to identify chemicals shipped to the building.	None that I use	Not typically used.
Do you have a record system that identifies waste streams from facilities during their operational phase?	We have a computerized Waste Information Tracking System with various approved waste streams that were used by the building before it entered the D&D program. This is useful information.	None that I use	Waste Information Data System
Do these provide radiological and/or hazardous waste characterization data?	Yes. Isotopic distribution of each waste stream is available generated during operations is available.	No	Yes
Do you have an environmental protection or regulatory affairs organization which maintains permits, effluent monitoring data and other potentially relevant historical information?	Yes	Yes	Yes

Lines of Inquiry	SRS Response	Paducah Response	Hanford Response
Do you have records of asbestos containing materials?	Yes, but samples are always taken.	Yes	Yes, but typically additional samples are collected to verify.
Do you have access to facility safety basis or authorization basis documents, including old revisions that may contain information on previous processes that occurred in facilities?	Yes	Yes	Yes
Do you use the documents?	Yes. Often very useful.	Yes	Yes, when applicable.
Do you have a formal program of identifying and interviewing past workers, including retirees?	No	Yes	Yes
Are interviews documented?	No	Yes	Yes
Who performs?	N/A	Various persons	Usually conducted during Data Quality Objective process by environmental/project representatives.
How do you decide who, how many, where to have?		Project specific requirements	Determined during Data Quality Objective process
How do you package all the above information?	Engineering general produces a characterization document.	Conversation reports	
Is there a single point of contact for a given facility or part of a facility?	Each facility is assigned to a project manager. Subject matter experts for each required discipline (engineering, environmental, Industrial Hygiene, etc.) are assigned to the IPT.	No	Information is documented in many places (environmental, radiological, nuclear safety, project execution, project controls, operations, surveillance and maintenance, etc.) based on type of information. Usually there is a manager assigned to a project. However, because the more complex projects take years to plan, obtain regulatory approval, and perform the manager changes several times through the life cycle of a project.

3.3 COMMERCIAL NUCLEAR FACILITIES

A key element of D&D planning focuses on the capture of historical information from facility operations. EPRI described approaches taken and experience gained in the development of early characterization activities by several commercial nuclear power plants undergoing decommissioning [4]. EPRI indicates that the Nuclear Regulatory Commission (NRC) endorses the use of the *Multi-Agency Radiation Site and Survey Investigation Manual (MARSSIM)* for decommissioning of commercial nuclear facilities. MARRSIM was developed jointly by the NRC, USEPA, DOE, and the Department of Defense to provide a consistent approach for planning site investigations. MARSSIM describes a graded site investigation process that starts with the Historical Site Assessment (HSA). EPRI reported lessons learned in conducting an HSA. As described below, the organizations performing these HSAs identified some best practices in the area of capturing historical process data.

The NRC in 10 CFR 50.75(g) provides key information for the development of an HSA. The following narrative is extracted from 10 CFR 50.75(g) as indicative of the record keeping that should be available for planning D&D of a NRC licensed reactor [4]:

"Each licensee shall keep records of information important to the safe and effective decommissioning of the facility in an identified location until the license is terminated by the Commission. If records of relevant information are kept for other purposes, reference to these records and their locations may be used. Information the Commission considers important to decommissioning consists of

1. Records of spills or other unusual occurrences involving the spread of contamination in and around the facility, equipment or site. These records may be limited to instances when significant contamination remains after any cleanup procedures or when there is reasonable likelihood that contaminants may have spread to inaccessible areas as in the case of possible seepage into porous materials such as concrete. These records must include any known information on identification of involved nuclides, quantities, forms and concentrations.
2. As-built drawings and modifications of structures and equipment in restricted areas where radioactive materials are used and/or stored and of locations of possible inaccessible contamination such as buried pipes which may be subject to contamination. If required drawings are referenced, each relevant drawing needs to be indexed individually. If drawings are not available, the licensee shall substitute appropriate records of available information concerning these areas and locations.
3. Records of the cost estimate performed for the decommissioning funding plan or of the amount certified for decommissioning, and records of the funding method used for assuring funds if either a funding plan or certification is used."

EPRI included the following questions in its investigation of methods of capturing historical knowledge for decommissioning nuclear power plants [4].

- Are you aware of or associated with the non routine storage of radioactive material (or asbestos, petroleum products, hazardous chemicals, Polychlorinated Biphenyls [PCBs], oil, solvents) on site?

- Are you aware of or associated with an effort to isolate or seal in a spill of radioactive material (or asbestos, petroleum products, hazardous chemicals, PCBs, oil, solvents) on site?
- Are you aware of or associated with a spill of radioactive material (or asbestos, petroleum products, hazardous chemicals, PCBs, oil, solvents) on site?
- Are you aware of or associated with inadequately covered bare lead on site?
- Are you aware of or associated with the release of radioactive material (or asbestos, petroleum products, hazardous chemicals, PCBs, oil, solvents) from any un-monitored pathway from site?
- Are you aware of any potential un-monitored release pathways from site?
- Are you aware of or associated with the storage on surface soils, asphalt or concrete of radioactive material (or asbestos, petroleum products, hazardous chemicals, PCBs, oil, solvents) on site?
- Are you aware of any fires or explosions which occurred on site?
- Are you aware of any excavations that have taken place on site?
- Are you aware of any subsurface tanks, piping, or components located on site?
- Area you aware of any areas that were used as landfills?
- Are you aware of any groundwater plumes without an identifiable source?
- Are you aware of any structures (permanent or temporary) that have shared HVAC or liquid (including drain) systems with the primary power block?
- Are you aware of any PCB containing material on-site, e.g., transformers, cable pull lubricant?
- Are you aware if lead based paint was used on-site?
- If the answer to any question is yes, describe the event and if known note any documentation which addresses the observation, and where to locate the documentation?
- Do you know of anyone else who should receive the questionnaire?

EPRI evaluated the historical data gathering processes used by eight commercial nuclear power plants that were in various stages of decommissioning. The data gathering approach and the sources of information used by each facility are summarized below [4].

3.3.1 Big Rock Point

Big Rock Point is a single unit facility located on Lake Michigan. The reactor first achieved criticality in 1962. Fuel was permanently removed from the reactor in 1997. An HSA, conforming to MARSSIM guidelines, was completed in 2002. The HSA, which served as the basis for the overall site characterization activity, produced a complete account in chronological order of all events involving both radiological and non-radiological materials with potential to impact natural environmental media. Known or potential contamination of structures was not assessed. "Investigation and physical inspection and process knowledge" were used to evaluate the historical event data. Sources of information included:

- The health physics logbook, 37-year continuous record of radiological activities and site conditions
- Employee and retiree questionnaires

- Corrective action records, including Deviation Reports, Event Reports and Condition Reports
- Interviews with past and present employees
- Physical walk down of site property
- Plant drawings
- Spill records
- Waste shipment records
- Hazardous material assessments

3.3.2 Connecticut Yankee

Connecticut Yankee, also known as Haddam Neck Plant is a single unit facility located in Haddam Neck, Connecticut. The initial reactor criticality occurred in 1967. Fuel was permanently removed from the reactor in 1996. An HSA, conforming to MARSSIM guidelines, was completed in 1999. A supplement to the HSA was completed in 2001. The HSA objective was to identify significant events that caused the contamination of systems, buildings, external surfaces and subsurface areas via liquid spills, atmospheric releases, or loss of control or radioactive material. For each event, available supporting documentation was collected and reviewed. Over 40,000 documents from among the following categories were reviewed:

- Radiological incident files
- Radiation protection survey records from 1967 to the time of the HSA
- Annual environmental reports
- Informal interviews with past and present employees, vendors and contractors
- Formal interviews with 47 people, based on questionnaires completed by employees concerning contamination issues
- Review of regulatory actions against the site
- Walk downs and inspections
- Routine and non-routine release reports to the NRC
- Incident reports
- Condition reports

3.3.3 Maine Yankee

Maine Yankee is a single unit facility located in Wiscasset, Maine. Commercial operations began in 1972 and ceased in 1996. An HSA, which was planned prior to the issuance of MARSSIM, was completed in 1998. However, the methods used were defensible in comparison to MARSSIM and the data collected were shown to be acceptable. Historical information included the 10 CFR50.75(g) file, employee interviews, radiological incident files, pre-operational survey data, spill reports, and special surveys.

In order to complete the investigation of events involving spills, leaks or other operational occurrences which might have an effect on the radiological and chemical status of the site, terminating employees were interviewed for their recollection of such events. All personnel

were informally interviewed. Advertisements were also placed in local newspapers which asked readers who were aware of spills or other contamination events to contact the site.

3.3.4 Rancho Seco

Rancho Seco, a single unit facility, is located in Herald, California. Initial criticality occurred in 1974. The reactor was permanently de-fueled in 1989. An HSA, which was planned prior to the issuance of MARSSIM, was completed in 2003.
The following were among the documents reviewed for the HSA:
Annual operational and environmental reports

- Environmental investigations performed by independent entities
- Radiological control surveys during the life of the plant
- Occurrence description reports
- Plant incident or condition reports
- Other regulatory reports submitted to various government agencies
- Records maintained to satisfy the requirements of 10 CFR50.75(g)
- Historical aerial photographs
- Written questionnaires and oral interviews with current and past facility employees, which generated about 150 observations[1]

3.3.5 Saxton

Saxton is a single unit facility located in Saxton, Pennsylvania. Initial criticality occurred in 1962. Operations ended in 1972. An HSA, which was planned prior to the issuance of MARSSIM, was completed in 2000. Saxton is somewhat unique in that it was constructed on the site of a commercial coal-fired steam generating plant known as the Saxton Steam Generating Station (SSGS), which operated between 1922 and 1974. SSGS was demolished between 1975 and 1977. Since SSGS operations could have contaminated environmental media prior to construction of Saxton on the same site, SSGS operations were included in the site HSA. The following information was gathered during the overall site HSA, which included the nuclear facility and SSGS:

- Interviews with former and current employees
- Review of the types and quantities of radioactive materials that were stored, handled, moved, relocated, produced and dispositioned
- Review of the types and quantities of radioactive materials likely to remain on the property
- SSGS drawings and blueprints
- Saxton and SSGS historic photographs
- Reactor daily operations summaries
- Facility radiological surveys

[1] It was noted that individuals recollection of events tended to categorize events as more significant than site documentation had determined.

Due to the age of the facility, many plant records were maintained in the original paper format, with a limited file indexing system. Approximately one man-year of effort was required to review these records. The 27-year period between the end of operations and the start of the HSA made it difficult to obtain historical records and find people knowledgeable of operations.

3.3.6 Three Mile Island 2 (TMI-2)

TMI-2 is one of two units at the site, which is near Middletown, Pennsylvania. Initial criticality occurred in 1978. Operations ended in 1979 as result of the famous accident. An HSA was conducted to collect information to document the contribution of TMI-2 to the radiological state of the entire TMI site. The HSA investigation included the following:

- Review of documents pertaining to the construction, operations, accident, post accident recovery, and reactor de-fueling history of TMI-2
- Interviews with current and former operations employees, contractor employees, and federal/state regulators
- Identification of types and quantities of radioactive materials that were stored, handled, moved, relocated, produced and dispositioned
- Identification of areas that were possibly affected by operations, the accident, de-fueling, post de-fueling, and monitored storage
- Identification of types and quantities of radioactive materials likely to be remaining
- Final Safety Analysis Report
- Various reports on the accident
- Current radiological surveys of TMI-2
- Shift foreman logs
- Control room operations logs

3.3.7 Trojan

Trojan is located in Columbia County, Oregon, north of Portland. Initial criticality occurred in 1975. Operations ceased in 1992. A formal HSA was not generated. However, a review was conducted of corrective action documents and reports to the Atomic Energy Commission, the NRC and the state of Oregon. Interviews were also conducted with former staff. Since decommissioning began shortly after permanent shut down using site personnel it was felt that interviewing retirees would provide no additional information.

3.3.8 Zion

Zion, located near Zion, Illinois on Lake Michigan, is a dual unit facility. Both units went critical in 1973. Operations ceased in 1997. During conduct of the HSA, over 29,000 documents and databases were reviewed. Two types of interview questionnaires were used in conducting the HSA. The first type was designed for permanent site production personnel. The second type was used during the personnel exit process for both permanent and contractor staff. Over 300 interviews were conducted.

3.4 UNITED STATE ARMY CORPS OF ENGINEERS (USACE)

USACE in its Engineering Manual EM 200-1-2 provides the planning guidance listed below to technical project teams for projects in general and specifically for those dealing with radioactive waste.

3.4.1 Gathering of Existing Site Information

USACE identifies existing site information and gathers the most pertinent data. The gathered information is compiled and included in team information packages [9]. This activity, coupled with Paragraph 3-5 of EM 200-1-2 is the equivalent of the MARSSIM HSA. Site information is obtained from a wide variety of other sources, including Atomic Energy Commission or NRC licenses and amendments, Army radiation authorizations, Air Force radiation permits, local land use permits, as well as the site owner or operator's records of past activities at the site. Additionally, USACE archivists experienced in gathering documents relating to sites are available. If possible, USACE attempts to obtain facility operating procedures and inventories, and define the receipt, use, storage, and disposal areas for the hazardous and radioactive materials on the site. A description of all the background literature is captured into a single document and made available to all data users and implementers [9].

3.4.2 Conduct of Preliminary Site Visit

If appropriate, a preliminary site visit is conducted to identify all potential sources of site information. Current and historical photographs of site conditions and operations are obtained. Preliminary site visits are also used to obtain site maps or drawings that depict critical site features (e.g., historical land use, buildings, tanks, topography, surface water locations, disposal/storage/staging areas, and treatment systems). It may also be beneficial to videotape the site and specific features [9].

3.4.3 Conduct of Site History Interviews

USACE plans discussions with former and current responsible employees about previous operations and waste handling. Employees and personnel interviewed include individuals involved with site operations, permitting, previous investigations, environmental and engineering personnel associated with the facility or site. All current and past property users with potential knowledge of contaminant releases are included. It is also crucial for the responsibility perspective to be involved to assure proper documentation is prepared and any related substantiation is considered [9]. Not only former and present site workers, but also past and present regulators and inspectors are considered for interview. Many sites using radioactive materials also had some form of area dose monitoring. These records may also prove valuable in estimating potential hazards at the site [9].

3.4.4 Gathering of Site Data and Reports

Some of the most pertinent data gathered are [9]:

- Site maps
- Site and aerial photographs
- Historical ownership information
- Regulatory status of the site and facility
- Facility or site-related geology
- Hydrogeology, hydrology, climatology, ecology, and demographic information about areas adjacent to the site
- Results and reports of previous site studies or investigations
- Known influence of other nearby sites

4.0 CONCLUSIONS

The definition of PK for D&D offered in section 2.5 indicates that it is a body of technical information about a given process. The survey of PK management practices presented in section 3.0 indicates that a robust body of PK needed for D&D contains a number of important elements, which can be organized into two major categories: process design and process history. These categories and the elements which comprise them are discussed below.

4.1 PROCESS DESIGN

Several key documents are typically used to define the design of process facilities in the process (chemical, paper, food and beverage chemicals, pharmaceuticals, petroleum, ceramics, base metals, plastics, rubber, textiles, tobacco, wood and wood products) industries in general and the nuclear industry in particular. There is a general consensus among experienced D&D practitioners that the process design documents listed below are particularly useful for facility D&D.

4.1.1 As-built Engineering Drawings and Documents

Engineering drawings and documents are used to sufficiently define the design of a process so that it may be constructed. In well managed facilities, these documents are maintained to match the installed configuration as it changes over time to meet evolving process needs. In fact, DOE O 420.1B, *Facility Safety*, defines a system engineer program for operating DOE nuclear facilities (hazard category 1, 2, and 3), which requires that the design basis of facility systems be kept current using formal change control and work control processes. Key process system design documents must be identified and consolidated to support facility operation. This body of design basis documentation forms the technical baseline for the facility during the operations and maintenance (O&M) phase of the facility life cycle. Since many D&D tasks are similar to those performed during the O&M life cycle phase, the O&M technical baseline is a key, if not an essential element of the PK required during the D&D phase of the facility life cycle. To deactivate, dismantle and remove process systems safely and efficiently, it is necessary to know their design. Therefore, accurate as-built process design information is an essential element of the PK needed for D&D.

This design information should be available for all hazard category 1, 2, and 3 facilities that operated after about 1990. For DOE process facilities whose hazard category is other than nuclear (i.e. radiological, chemical, or other industrial), the information may also be available because the same technical baseline requirements may have been applied for these facilities at some sites for consistency, even though not required by DOE order. If the facility ceased operations prior to 1990, the available technical baseline information is not likely to be as rigorous or accurate as for post-1990 facilities.

Specific categories of documents that define the design of a process typically include the following.

4.1.1.1 Process and Instrumentation Diagrams (P&IDs)

P&IDs (sometimes also called piping and instrumentation diagrams) schematically identify equipment items such as vessels, heat exchangers, pumps, valves and the piping that interconnects them. The material flowing through the equipment is often identified. Equipment items are sometimes named or numbered. Pipe lines may even be numbered and materials of construction and sizes indicated. The PK presented on these drawings is extremely useful for preparing tap and drain plans and estimating waste volume. The PK depicted on P&IDs is often sufficient to characterize the material and equipment shown for disposal. The P&ID is one of the most useful elements of PK needed for D&D. An example of a simplified P&ID is shown in Figure 1.

4.1.1.2 Process Flow Diagrams

Process flow diagrams present a higher level view of the process design than P&IDs. Individual equipment items are not shown. Process unit operations and materials are typically shown schematically using blocks with arrows used to show the interconnecting material flow paths. A flow diagram for the UREX process is shown in Figure 2.

Process flow diagrams help D&D engineers know what materials flowed through the various process unit operations and individual equipment items such as tanks, pumps, and piping. They may even allow compositions or concentrations of specific process chemicals and radionuclides to be determined. Consequently, they are a significant element of the body of PK needed for facility D&D.

4.1.1.3 Equipment Arrangements

Equipment arrangement drawings present the physical layout of equipment items in the facility. These drawings are very useful because they show the relationship between equipment items and provide dimensions of the items and distances between them and structures such as walls, floors, etc. This information is helpful in removing and disposing of the equipment.

4.1.1.4 Specifications for Materials and Process Equipment

Often the characteristics of process feed materials and products are controlled by documented material specifications. For example the isotopic distribution or chemical composition of a feed or product stream may be administratively controlled by written specification. This PK may be sufficient to characterize materials and items contaminated with those materials for disposal as waste. Likewise, procurement specifications for equipment items often provide good information that can aid in dismantling and disposing of equipment.

4.1.1.5 Master Equipment List

Newer facilities usually have a master equipment list (MEL). In fact maintaining an up to date MEL is required by the DOE system engineer program. If available, the MEL is an excellent starting point for D&D planning. If not available, the scope of equipment removal required for D&D will have to be developed from facility walkdowns.

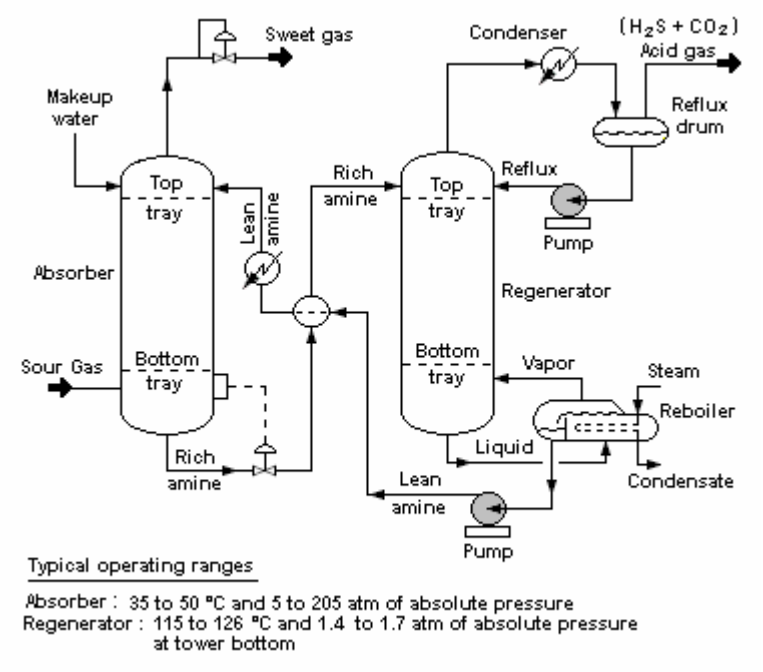

Figure 1 Example of a Process and Instrument Diagram [10]

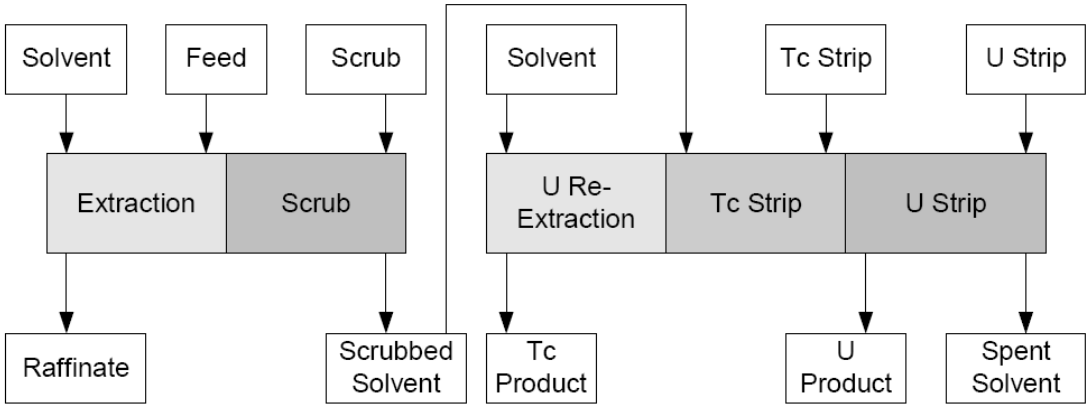

Figure 2 UREX Process for Uranium [11]

4.1.1.6 Instrument List

The instrument list is useful in identifying components that will require removal and management as RCRA hazardous waste. For example, the list may make it possible to easily identify mercury thermostats and switches, components with circuit boards, and brass constituents that must be segregated and managed as hazardous waste.

4.1.1.7 Line List

During process design, a list or table of process lines is typically developed. This list usually identifies each line by line number. Such information is useful for the same reasons discussed above for PI&Ds.

4.1.1.8 System Design Description

System design descriptions (SDDs) are sometimes available for newer facilities. Well done SDDs provide a wealth of information on facility systems which is extremely useful for D&D planning.

4.1.1.9 Valve List

Valve lists are useful to aid in identifying the number of brass and bronze valves that may need to be managed as hazardous waste due to lead content.

4.1.2 Equipment Vendor Documents

Vendor print files and technical manuals are very useful in identifying critical information about individual equipment items such as composition of equipment internals (lead, brass, beryllium, etc.), surface areas that may have been exposed to contamination, and void spaces where bulk process materials may have accumulated. This information is also helpful in characterizing the equipment for disposal and in planning for removal and size reduction of the equipment for packaging and disposal.

4.2 OPERATIONS TRAINING MANUALS

Operations training manuals have proven to be very useful for D&D planning. They provide knowledge of how the process operated, which is not always obvious from drawings alone. In fact, a well prepared training manual may possibly be the best single source of information about a process because it often includes up to date flow diagrams and simplified P&IDs.

4.3 SAFETY BASIS DOCUMENTS

These documents discuss the processes that are authorized by DOE to operate in the facility and types of materials that can be processed. They often give insight into location of hazardous materials in the facility. The following documents comprising the facility's authorization basis for operations, deactivation, and/or S&M, should be examined if available [12]:

- Safety Analysis Report (or Safety Assessment)
- Other Safety Analyses
- Hazard Classification Documents (or Preliminary Hazards Analysis)
- Technical Safety Requirements (or Technical Specification, or Limiting Conditions Document)
- DOE-issued safety evaluation reports
- Facility-specific commitments regarding compliance with DOE Orders and Policies

4.4 PROCESS HISTORY

Knowledge of the history of process operations is a major component of the process knowledge needed for D&D. In many older facilities in the DOE complex, entire processes were installed, operated for a few years, dismantled and removed to allow newer processes to be installed in the same valuable space. For example, at the Y-12 National Security Complex at Oak Ridge, an electromagnetic uranium isotope separation process, employing what were called calutrons was originally installed in a facility there. The contaminants of concern (COCs) left behind in the building components and support systems (e.g. ventilation system) as result of calutron operations would be expected to include various isotopes of uranium.

When this process became obsolete due to the superior performance of isotope separation by gaseous diffusion, the calutron equipment was removed. The facility was then used for lithium enrichment using the Column Exchange (COLEX) process. It is known that the COLEX process used large quantities of mercury. The COCs left behind as a result of COLEX operations would, of course, be different from those left by the earlier uranium process. The COLEX process also eventually became obsolete and all its equipment was removed. The facility was then used for processing uranium and beryllium. As a result of these operations beryllium must be added to the list of COCs that D&D planners must be concerned with. If the D&D IPT had no historical information on previously removed processes, but did all their planning based on the installed processes it found when the facility was transitioned to D&D, the team may by totally unprepared for the consequences of encountering large amounts if mercury during the D&D process. A surprise of this magnitude would likely have major impact on the project schedule and baseline estimate when it became apparent. Thus, it is critical for effective planning to understand what campaigns were run with various process materials. The D&D engineer must also be aware that the same equipment was often used for different materials over time (various isotopic mixtures of Pu, Np, etc.).

DOE has provided guidance elsewhere recommending that the following facility operating and S&M documents and information be reviewed by D&D planners [12]:

- Records of nuclear and chemical materials used
- Records of nuclear and chemical materials stored
- Records of spills and leaks
- Records of on-site disposals, if any
- Facility drawings
- Deactivation final report
- S&M plan
- S&M records and annual reports
- Lessons learned reports
- DOE Occurrence Reporting and Processing System (ORPS) database events for the facility
- Information in FIMS

4.4.1 Methods of Gathering Process History

There are several methods of gathering process history at DOE facilities. Three of the most productive are listed below.

4.4.1.1 Review of Production and Technical Reports from the Operations Phase of Facility Lifecycle

Especially in the early days of the weapons complex when production processes were constantly being modified to accommodate new technical information from laboratory research and rapidly changing needs for materials and components, facilities typically documented performance by issuing periodic (e.g. monthly) production and technical reports. These often described the production campaigns that occurred in the facility and documented material throughput, operating conditions and typical problems that were encountered. This kind of information is useful in understanding why certain facility modifications were made (e.g. lines that became plugged and were abandoned in place, spaces sealed with contamination inside, contaminated surfaces grouted or painted over, etc.).

Much valuable information on relatively recent events may be found in the DOE ORPS database for incidents since 1992. The Office of Environment, Health, Safety and Security is responsible for maintaining this unclassified central database (see http://www.hss.energy.gov/CSA/analysis/orps/orps.html). ORPS is described in DOE O 231.1A, Environment, Safety and Health Reporting, and its associated Manual, DOE M 231.1-2, Occurrence Reporting and Processing of Operations Information. Other related documents are DOE G 231.1-1, Occurrence Reporting and Performance Analysis Guide, and DOE G 231.1-2, Occurrence Reporting Causal Analysis Guide.

Useful information may also be obtained from special studies that were performed, such as dose reconstruction studies that identify the radionuclides processed in different portions of the facility at various times in its history.

4.4.1.2 Historical Site Assessments

As discussed in section 3.3, MARSSIM describes a graded site investigation process that starts with the HSA. The first phase of the HSA process, known as the Preliminary HSA, focuses on gathering existing data about the facility and its level of contamination [5]. MARSSIM recommends that the following records and other information sources be gathered for review [5]:

- Records describing onsite activities
- Current and past contamination control procedures
- Records of past operations involving demolition, effluent releases, discharge to sewers or onsite septic systems, production of residues, land filling, waste and material storage, pipe and tank leaks, spills and accidental releases, release of facilities or equipment from radiological controls, and onsite or offsite radioactive and hazardous waste disposal

MARSSIM advises that past operations be summarized in chronological order along with information indicating the type of permits and approvals that authorized these operations. Estimates of the total activity disposed of or released at the site and the physical and chemical form of the radioactive material should also be included. Records on waste disposal, environmental monitoring, site inspection reports, license applications, operational

permits, waste disposal material balance and inventory sheets, and purchase orders for radioactive materials are useful for estimating total activity. Information on accidents, such as fires, flooding, spills, unintentional releases, or leakage, should be collected as potential sources of contamination. Possible areas of localized contamination should be identified [5].

Site plot plans, blueprints, drawings, and sketches of structures are especially useful to illustrate the location and layout of buildings on the site. Site photographs, aerial surveys, and maps can help verify the accuracy of these drawings or indicate changes after the time when the drawings were prepared. Processing locations and waste streams to and from the site as well as the presence of stockpiles of raw materials and finished product should be noted on these photographs and maps. Buildings or outdoor processing areas may have been modified or reconfigured such that former processing areas were converted to other uses or configurations. The locations of sewers, pipelines, electric lines, water lines, etc., should also be identified. This information facilitates planning the site reconnaissance and subsequent surveys, developing a site conceptual model, and increasing the efficiency of the survey program [5].

Corporate contract files may also provide useful information during subsequent stages of the radiation survey and site investigation process. Older facilities may not have complete operational records, especially for obsolete or discontinued processes. Financial records may also provide information on purchasing and shipping that in turn help to reconstruct a site's operational history [5].

While operating records can be useful tools during the HSA, the investigator should be careful not to place too much emphasis on this type of data. These records are often incomplete and lack information on substances previously not considered hazardous. Out-of-date drawings may not show modifications made during the lifetime of a facility [5].

4.4.1.3 Interviews with Current and Retired Personnel

Interviews should be conducted as part of the HSA. In many cases there may be no easily retrievable information on the history of operations in a particular facility. The only source of information about past operation may be the memories of personnel who worked in the facility at the time. In fact, even if written documentation concerning the facility and its operating history exists, a comprehensive PK acquisition program should include interviews with as many knowledgeable people as practical. However, it must be recognized that human memory is not completely accurate. Therefore, it is likely that some faulty information will be obtained and some important information will inevitably be lost to incomplete memory. For this reason, the vagaries of human memory should not form the complete foundation of a PK (or even a PH) gathering program. The collection of verbal information based on memory should supplement a PK program based on a foundation of maximum use of available engineering documentation and other written reports. See section 2.4.4 for a discussion of knowledge elicitation methods.

The main purpose of the HSA is to determine the current status of the site or facility, but the data collected may also be used to differentiate sites that need further action from those that pose little or no threat to human health and the environment. This screening process can

serve to provide a site disposition recommendation or to recommend additional surveys. Because much of the data collected during HSA activities is qualitative or is analytical data of unknown quality, many decisions regarding a site are the result of professional judgment [5].

In most cases it is assumed there will be some level of process knowledge available in addition to historical analytical data. If process knowledge suggests that no residual contamination should be present and the historical analytical data also suggests that no residual contamination is present, the process knowledge provides an additional level of confidence and supports classifying the area as non-impacted. However, if process knowledge suggests no residual contamination should be present but the historical analytical data indicate the presence of residual contamination, the area will probably be considered impacted [5].

5.0 RECOMMENDATIONS

A minimum level of knowledge about a process facility is needed to safely and efficiently conduct D&D. This knowledge may have been captured in official facility documents such as design drawings, specifications, normal operations reports, training manuals, and historical information concerning abnormal events such as occurrence and spill reports. In many cases the required information exists only in the heads of current and past workers.

It is apparent that different segments of the nuclear industry faced with the common problem of gathering the required information for D&D have developed a set of practices with many common elements.

As stated in section 2.3, the guidance in this document is primarily focused on the various types of organizations that have been tasked with conducting or reviewing a facility D&D project. However, another type of user is the operating organization tasked with transitioning a facility from the operations phase of its life cycle to S&M mode in anticipation of D&D at a future date. This group of users must be aware of the types of PK that the eventual D&D project team will need to place the facility in its final end state. Recommendations appropriate for each group of users are provided below.

5.1 RECOMMENDATIONS FOR D&D PROJECT EXECUTION AND INDEPENDENT REVIEW TEAMS

For teams assigned to conduct or review a facility D&D project, the following approach is recommended based on the conclusions presented in section 4.0 as to what constitutes a desirable body of PK to support an effective and efficient D&D project.

5.1.1 Knowledge Management Area

It is recommended that a formal PK management program be developed. Consider centralizing program responsibility in the position of HIM. See sections 3.1.1 and 3.1.2 for approaches taken by SNL and LLNL, respectively. Combined, these approaches are considered best practices in the area or knowledge management.

The HIM should set up a paper or electronic document management system which is accessible to all project team members. This system should contain all the key facility process design documents discussed in section 4.1 and its subsections. Specific recommendations identifying key elements of process design to be collected are discussed below in section 5.1.2.

The HIM should also manage the interview process, including arranging, performing and documenting interviews with current and former employees who have been identified by project team members as potential sources of information. The HIM should seek help from people experienced in the interview process or be willing to become an expert in this discipline.

Both EPRI and SNL made the key point that elicited knowledge must be validated by appropriate personnel before it is used as a basis for action. Such knowledge must be considered invalid until it can be shown to be accurate. It is risky to rely solely on the memory of even the most conscientious and knowledgeable employee to reconstruct events that may have occurred a decade or more earlier. SNL reduces the risk of making inappropriate D&D planning decisions based on faulty memory by formalizing the review of data gathered during a site assessment. SNL requires that subject matter experts evaluate the gathered data for completeness, reliability, and consistency with other relevant data. This practice is recommended.

5.1.2 Process Design Documents

As concluded in section 4.1, several key documents which define the design of process facilities have been found useful by D&D project teams. Therefore, the following categories of documents are recommended to be collected and made available to members of the project team to perform their individual functions.

- P&IDs
- Process Flow Diagrams
- Equipment Arrangements
- Specifications for Materials and Process Equipment
- Master Equipment List
- Line List
- System Design Description
- Equipment Vendor Documents
- Operations Training Manuals
- Safety Basis Documents

The reader is referred to section 4.1.1 for a detailed description of these documents and why they may be useful to D&D project teams.

5.1.3 Process History Documentation

Experience has shown that, in addition to understanding the facility design, D&D project teams must know the history of facility operations in order to plan for the various types of hazards that will be encountered during D&D activities. As detailed in section 4.4, several types of historical records have been demonstrated to yield valuable information about the facility and its potential hazards and contaminants. The following documents are recommended for review by the D&D project team.

- Records of nuclear and chemical materials used or stored
- Records of spills and leaks
- Records of on-site disposals, if any
- Deactivation final report
- S&M plan
- Production reports

- S&M records and annual reports
- Lessons learned reports
- DOE ORPS database events for the facility
- Technical reports related to process development or performance
- Results of interviews with people knowledgeable of facility history
- Radiological surveys during the life of the facility
- Historical aerial photographs
- Control room operating logs
- MC&A reports
- Facility condition reports or assessments

Many experienced D&D planners employ the graded but systematic approach to process history gathering known as the HSA. As presented in section 4.4.1.2, the HSA is described in MARSSIM, which has been endorsed by the NRC, USEPA, DOE and the Department of Defense, all of which are key players in decommissioning of contaminated facilities (see also section 3.3). Therefore, it is recommended that D&D project teams become generally familiar with the methodologies presented in MARSSIM and specifically that they employ the HSA methodology to acquire the historical process information required for facility D&D.

5.2 RECOMMENDATIONS FOR FACILITY TRANSTION TEAMS

The recommendations made in section 5.1 for D&D project execution teams and independent review teams are also applicable to facility transition teams. Facility transition teams should establish a formal knowledge management program to capture and store the currently available PK for future users before it is lost. The types to be of PK described in sections 5.1.2 and 5.1.3 should be captured and stored by the transition HIM. In addition, the DOE Transition Implementation Guide provides recommendations (worth repeating here) for PK to be captured by the facility transition team for future use by D&D projected teams [13]:

- An operating history (including previous operational records) of the facility giving the process knowledge of the nuclear and chemical materials that were handled and major spills or leaks that occurred
- A description of the condition of all structures, existing engineered protective barriers, and systems installed to prevent migration of both hazardous and radioactive contamination to the environment and that ensure the safety of workers, the public, and the environment
- A description of the nature, levels, and probable extent of the existing hazardous chemical contamination, the radiological contamination, and direct radiation fields within and around the facility
- An accurate and complete inventory (including associated uncertainties) of types, forms, quantities, and locations of all special nuclear and fissionable materials
- An inventory or estimate and the locations of the remaining hazardous material, waste and chemical inventories, and any associated uncertainty, including form and distribution information

- The occupational hazards associated with the facility. This evaluation should focus on fixed hazards. Temporary occupational hazards created to support operations and maintenance should be removed by the operations organization.
- Current radiological survey data, which will be used to identify barriers necessary to protect the public and the environment and define the radiological working conditions, equipment (e.g., containment, protective clothing, etc.) or procedures that protect the worker.
- The facility's shutdown status. As a minimum, the facility safety envelope; S&M requirements; the preservation of facility structures, systems, and components; safeguards and security; emergency plans and procedures should be addressed. Baseline information on energy utilities systems and services should also be included.
- A list of—
  - documents that define the authorization basis and the S&M requirements necessary to maintain the current safety envelope of the facility;
  - applicable permits, licenses, and agreements that remain imposed on the facility;
  - outstanding commitments to regulatory authorities, tribal governments, stakeholders, and DOE organizations that require action; and
  - excess equipment and material not required to operate and maintain the facility and that is planned to be removed from the facility
- Information on any other factors such as potential future use, long-range site plans, facility condition, and potential health, safety, and environmental hazards that could influence the selection of decommissioning alternatives (safe storage, entombment, dismantlement, etc.) or deactivation alternatives (thermal stabilization, residue elimination, separation of utilities, etc.).

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